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ECL 263

EXCESSIVE WORKPLACE NOISE IN THE "POLYMER" DEPARTMENT

The evolution of an effort to protect workers from excessive noise at a polymer grinding facility, from the discovery of high noise levels to the final engineering solution. Included are sound measuring techniques, short-term worker protection, conceptualization and evaluation of different methods of noise control, technical considerations concerning the nature of sound and of acoustical materials, and the examination of different types of chemical processing machinery. The human element is also presented with Management/Union interactions, rivalry, and uncertainty. Drawings are used to illustrate equipment layout, sound-level profies, and the engineering solution.

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EXCESSIVE WORKPLACE NOISE IN THE "POLYMER" DEPARTMENT (A)

Rick had just returned from his daily safety inspection at the construction site. It was company policy to inspect the area before approving a "hot-work" permit for welding, especially if the work were being done by an outside contractor not familiar with the plant. Now it was time to get a cup of coffee and tackle his desk full of paperwork.

"Boy," he thought, "there are more forms and reports to fill out every day. Being a Safety Engineer is strange: if you do a good job and everything runs smoothly, you begin to believe nobody notices you." He knew, though, that the people at headquarters were glad his programs were reducing the number of accidents and injuries.

The phone rang. It was Walt, the Plant Safety and Health Manager.

"Rick, this is Walt. Could you come over to my office for a minute? We've got a problem."

"Sure, I'll be right over" Rick answered. "Should I bring any particular files or data?"

"Yes. Good thinking. Do you have a floor plan of the 'Poly' department?"

Rick knew the "Poly" department was a brand new facility. What kind of problem could there be?

"Sure do, Walt. I'll bring it along."

Rick was out of his office in a minute, blueprint in hand. As he walked, his mind reviewed the "Poly" department layout. It was straight forward. Two reactors (see Exhibit A-1, A-2) carried out the chemical reaction of the raw materials in water, yielding a thick, honey-like solution. When this solution reached a predetermined viscosity the reaction was complete, and the operators pumped the material to the large dryers where it was sprayed onto heated conveyor belts, slowly carried through large sheet metal tunnels, and heated by hot air streams (gas fired) to remove all water from the polymer. Once dried, the polymer was a brittle material that broke into lumps and easily fell from the conveyor belts into rotating-screw feeders that carried it to the grinding mills. The friable lumps of product were easily reduced to powder by the powerful mills, and then swept from the mills in an air-conveying stream to the final product hopper. The powder was drawn from the hopper to bagging machines where operators filled and palletized 50 lb. bags.

It was a nice operation. With twin production lines

they could always produce product, even if one line broke down, and sometimes they even produced two different products by simply holding a batch in one reactor until the product from the other line was dried and bagged. It ran 24 hours a day, and it was profitable.

"Come in, and close the door" Walt said immediately as Rick reached his office. There was a disturbed note in his voice. With the blueprint spread on his desk, Walt explained the problem.

"I've just received some disturbing news, Rick. Remember when I conducted a noise-exposure survey in 'Poly' last week? Those were recording/integrating sound level meters that I had the workers wear for their shifts. They 'listen' to all of the sounds the worker is exposed to, and then we can average the reading to determine the average exposure levels. I got readings of 93-95 decibels for the bagging operators. That's not allowed by O.S.H.A."*

"95 decibels!?" queried Rick. "That can't be right. I was in there yesterday talking to one of the baggers about his new car, and I didn't have to scream in his ear."

"I don't understand it either, Rick. That's why I'd like you to 'look into' it a little further."

As Rick left Walt's office, he was already thinking "how should I proceed?" There were a number of immediate considerations to be weighed. Rick returned to his office. What should he do? How should he proceed?

Immediately after lunch Rick went downstairs to the instrument room and found the sound measuring equipment. He removed the instruction booklets and returned to his office, where he read them until he completely understood how the equipment functioned. It seemed logical to verify the calibration of the instruments used to conduct the plant noise tests. After all, if the instruments were not telling the truth, he could be starting on a "wild goose chase." The instruments all proved to be properly calibrated.

Being methodical, Rick planned his next step.

*Part 1910.95 of the O.S.H.A. Standards, Chapter 17 of Title 29, Code of Federal Regulations. The Permissible Exposure Limit (PEL), and all measurements pertinent to the PEL, are based on an A-weighted sound level (dBA).

At 7:45 the next morning--just before the shift started--Rick was in the "Poly" department with two of the recording/integrating sound level meters to re-run the exposure tests.

"We wore these meters just a few days ago" challenged one of the operators. "What's up?"

"I'd like to double-check my readings" was the answer.

That day Rick made it a point to go to the "Poly" department as often as possible. At the end of the day he took the meters and read the results: 93-95 decibels average exposure. This verified the previous test.

There was still nothing to report to Walt, Rick knew. He couldn't report that all he had done was to prove Walt's readings; he had to know what was causing the noise. Tomorrow he would do another noise survey, but this time he would use the "real time" meter.

The next morning, after coffee break, Rick went to the "Poly" department. The men were bagging product when he walked in.

"What did we do, win a popularity contest?" chuckled an operator. "This is the second day in a row that you're over in this department."

"I didn't want you fellows to get lonely, so I thought I'd 'drop by' and get some more readings. Tell me, how's everything running today?"

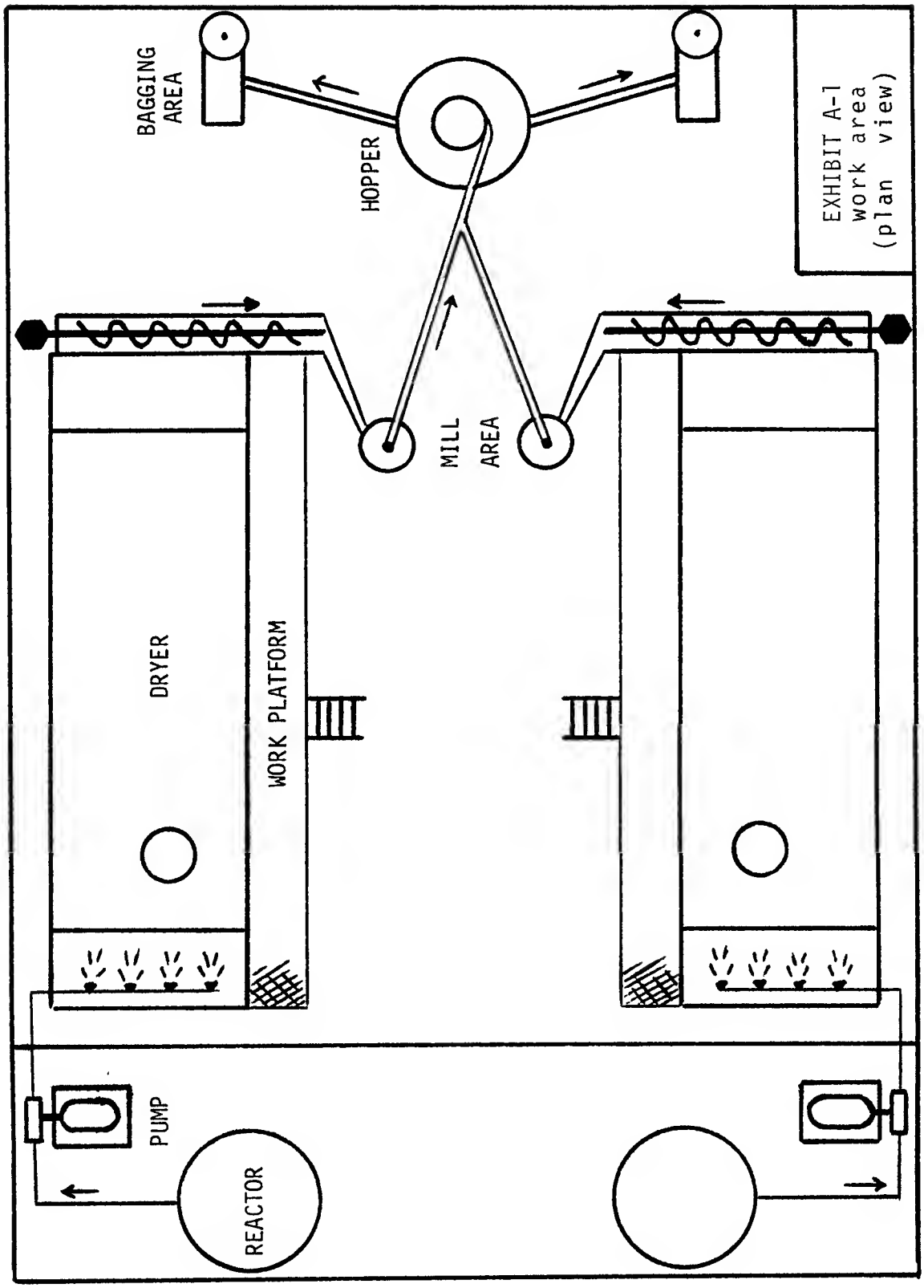
"Running O.K." added the other bagger.

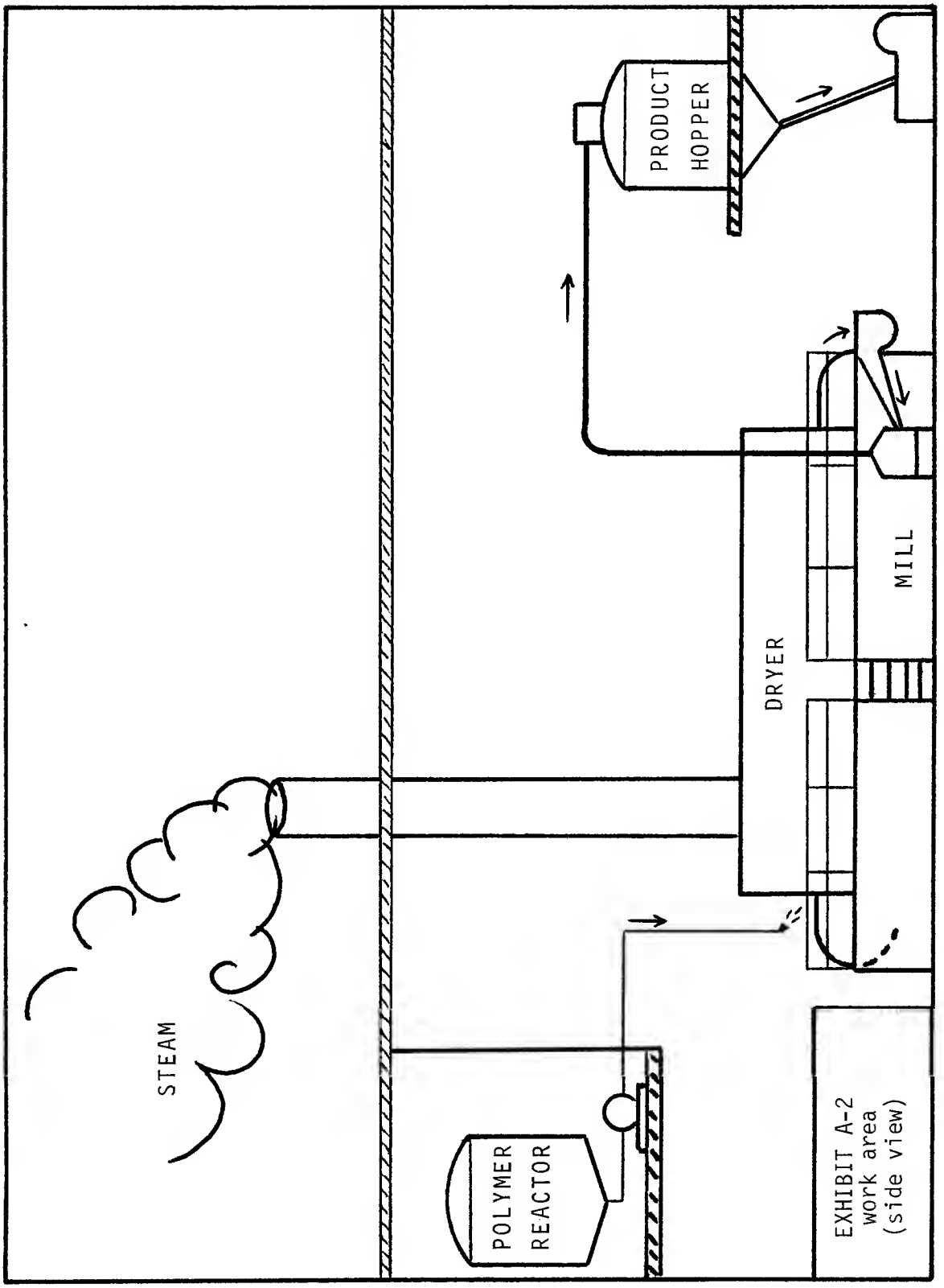
Rick turned the sound meter on and began to take readings near the bagging stations. Sound levels were about 85 decibels--noisy, but tolerable--in the entire area. It didn't make sense. Rick knew the decibel scale was not linear, and that a reading of 85 decibels was considerably lower than the 95 decibel readings he recorded the day before. Rick could hear loud equipment noises from the dryer area and walked toward the source. Immediately he realized the powerful mills were running and emitting high-pitched snarls not unlike "revved-up" motorcycle engines. The needle on the meter climbed to 90 decibels, then 95, then over 100. His ears rattled as if someone were running a giant chainsaw in his head. The needle crept past 105, and finally stopped at almost 110 decibels by the mill's air intake. Rick backed away and looked at the mills.

"Of course! I should have realized!" he thought.

"Those mills turn at such high RPM to shatter the polymer lumps (see Exhibit A-3) that all those impacts make a tremendous racket. This has to be the problem!"

Rick continued his survey in the dryer area. He found the alleyway between the dryers was a regular "no-man's-land" of noise levels (see Exhibit A-4), with readings well over 90 decibels. Before he could even wonder why a high noise level in the dryer area would cause high exposure to the operators, a buzzer sounded and Rick watched as an operator walked over to adjust the dryer temperature with controls atop the dryer. The platform area was almost painfully noisy. It was time to report back to Walt.


BAGGING AREA
HOPPER
EXHIBIT A-1
work area
(plan view)
MILL AREA
DRYER
WORK PLATFORM
PUMP
REACTOR


STEAM
POLYMER REACTOR
DRYER
MILL
PRODUCT HOPPER
EXHIBIT A-2
work area
(side view)

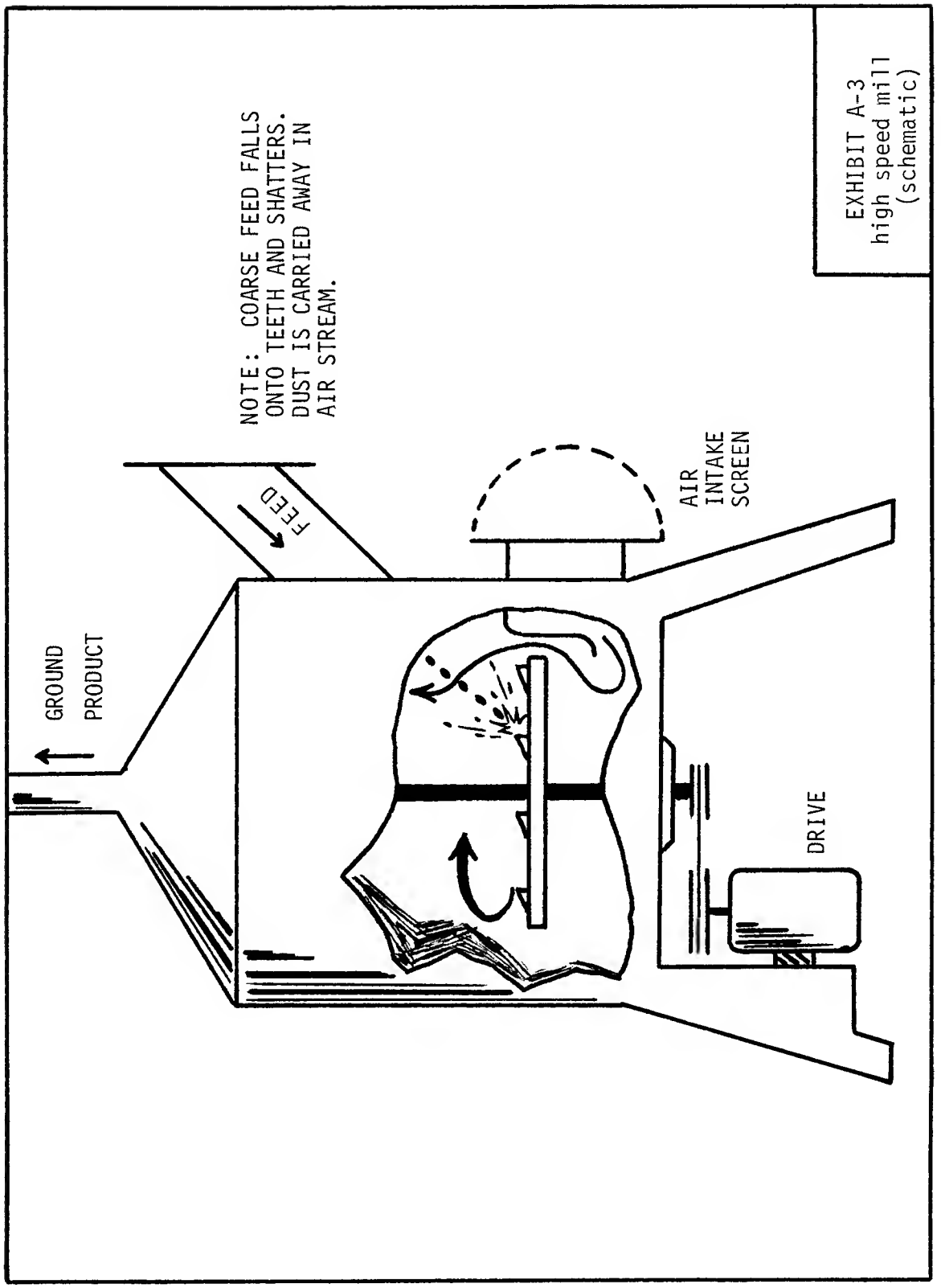
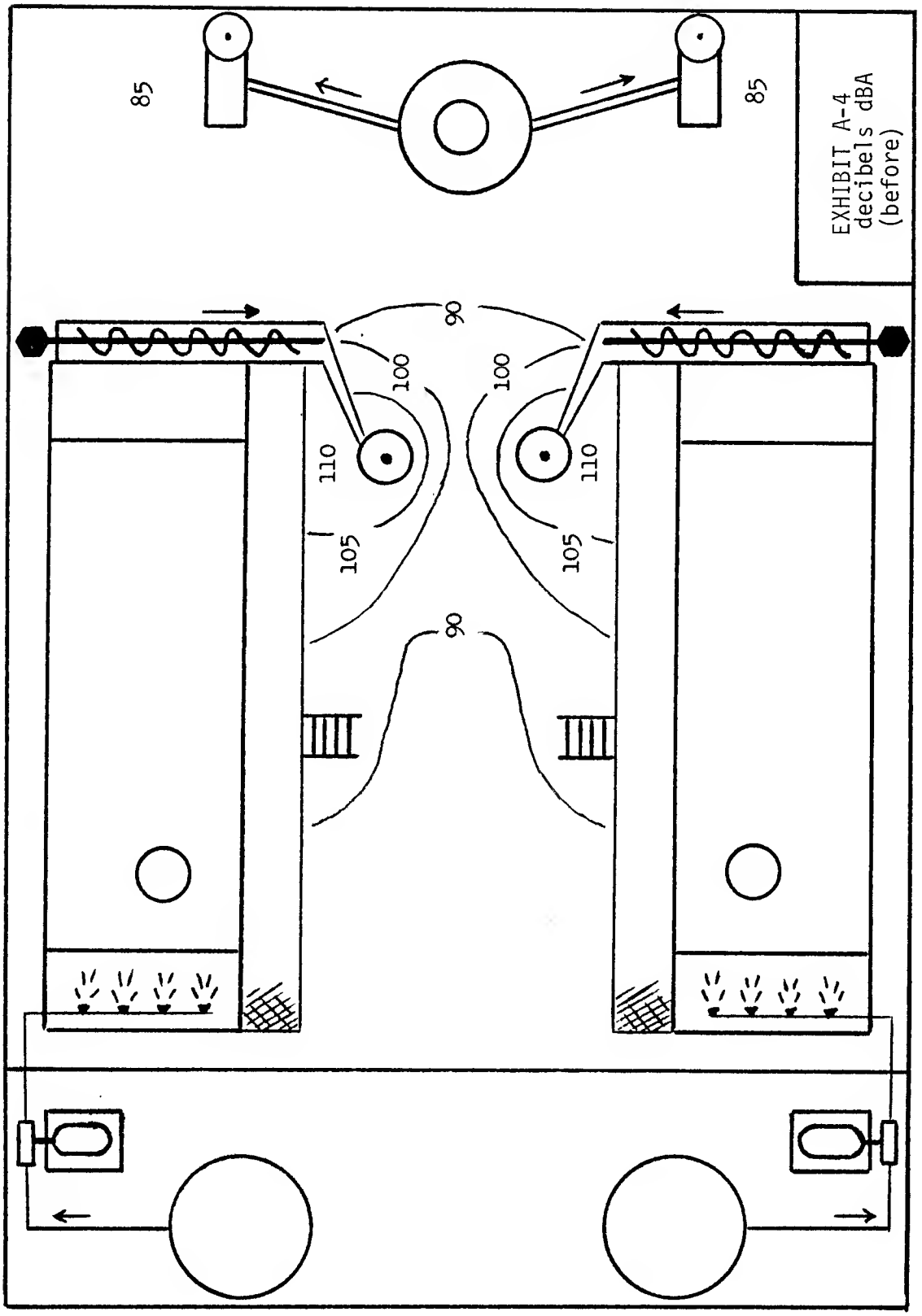


EXHIBIT A-3
high speed mill
(schematic)
NOTE: COARSE FEED FALLS ONTO TEETH AND SHATTERS. DUST IS CARRIED AWAY IN AIR STREAM.
FEED
AIR INTAKE SCREEN
GROUND PRODUCT
DRIVE


85
85
EXHIBIT A-4
decibels dBA
(before)
90
100
100
110
110
105
105
90

Questions

1) What was wrong with the assignment Walt gave to Rick?

2) What are some of the "immediate considerations" that might have been going through Rick's mind as he left Walt's office?

3) When asked why he was re-testing, why didn't Rick just tell the operator that noise exposure was too high?

4) While he ran the eight hour tests, why did Rick go to the "Poly" department frequently?

5) When Rick returned the second day with the "real time" meter, why did he ask "How's everything running today?"

6) Why was it so noisy between the dryers?

EXCESSIVE WORKPLACE NOISE IN THE "POLYMER" DEPARTMENT (B)

As he explained the results of the studies to Walt, Rick had mixed feelings: should he be proud that he found the noise source, or embarrassed that he didn't think of the loud mills immediately?

"It's definitely the mills, Walt. I got the same readings that you did, and I got readings over 105 right at the mill intakes. What should we do?"

"Good question. Did you tell anyone else the results?"

"No."

"Well, Rick, at least we don't have to worry about any 'pressure' then. Suppose we just kept this secret to ourselves? I mean, it's not as if the noise will hurt them like a cut or fall would. Besides, how can we stop a noisy machine? Shut it down? The 'Poly' department is a very profitable operation, you know. I don't like to just ignore a problem, but I'm 'stumped'. Got any ideas?"

"Not off the top of my head. I'd like to think about it for a while, though, and see if we can come up with something."

Later, back at his office, Rick pondered the situation. Did Walt really plan to sweep this problem under the carpet? It seemed so out-of-character for Walt because he was such a dedicated safety professional: when the fire brigade needed training, it was Walt who spent a Saturday organizing them; if a new product was proposed, it was Walt who reviewed the manufacturing procedures to make sure they were safe; and when it came down to fighting for safety-effort funds in the budget, Walt was a regular tiger. Yet here was a safety problem, and Walt seemed to just turn away.

"Let's be logical about this" thought Rick. "I can come up with as many solutions as possible, consider the pros-and-cons, and narrow the list down to a few of the best actions that I can discuss with Walt." The "gears" in Rick's mind turned faster.

"I could propose that we discontinue the profitable 'Poly' operation. Boy, would that be a 'no-win' solution--if I propose it to the 'brass' they would probably laugh at me and never consider my career again; the plant would keep running anyway; workers might suffer hearing damage; and there could be lawsuits--if I'm successful everyone would be laid-off. I would be foolish to even think of suggesting a 'shut-down'."

"On the other hand, suppose I did just ignore the problem? The workers would soon forget about the noise surveys and would keep on working, day after day. You can't 'see' noise, so it's easy to forget, and hearing-loss is so gradual that nobody would notice if it happened. We could probably run for years without trouble. But why should I use a double standard for worker safety? I wouldn't even think of letting the workers handle dusty silica without at least dust masks for fear they could inhale the dust and unknowingly develop silicosis over the years, so why should I ignore hearing damage just because it's gradual? And suppose a worker's spouse notices the radio being played a little louder each week? Could there be hearing-loss claims and lawsuits? Each operator could become a claimant and be awarded thousands in settlement, not to mention legal costs. Suppose it could be proved that I knew there were unsafe working conditions and ignored the danger--would I be responsible? If I ignore the problem it won't just 'go away'. I'm not going to suggest 'no action' as a solution, either."

"There must be something I can do. If I had workers handling acids I'd require safety goggles and a vinyl suit, and if workers were handling silica or asbestos I'd issue the proper respiratory protection immediately. Perhaps I should require hearing protection--I'll require 'earmuffs'!"

Rick was pleased with himself. He had a solution that could be applied almost immediately, wasn't at all costly, and would surely meet with Walt's approval. Rick ordered the equipment.

One week later, as Rick and Walt watched the "Poly" department workers being issued the hearing protectors by the shift foreman, they were both pleased. The foreman explained that the workplace noise was too loud, and that prolonged exposure could lead to hearing loss. He emphasized that hearing protectors were "required equipment" in the "Poly" area, and that no hearing protector was helpful if it weren't worn. Not surprisedly, the union Safety Steward--always very concerned with plant safety--agreed entirely with the foreman and pledged full union support.

"Ya know," commented the steward, "I'm always glad to see the company's interest in worker safety. We've come a long way since the 'old days' when I started here. Nobody knew about all this safety stuff, and it was just a fact of life if a riveter or boilermaker went deaf. Today things are a lot safer. In fact, the union even sent me to a class to learn all the new equipment and techniques just so's I could keep the company on its toes. I like the 'earmuffs'

as a temporary solution, but what other approaches will you take? I mean, in summer when it gets over 100 degrees it'll probably be very uncomfortable to wear earmuffs. The workers will probably start to take them off."

"We're working on it" Walt stated authoritatively. "It'll take some time. Until then, though, it's company policy that hearing protection is required in this area. We've even got signs ordered to put on all the doors."

Rick was silent. He realized the steward was right and that part 1910.95 required engineering control of excessive occupational noise exposure. Fortunately it was early spring, and temperatures would be cool for months yet. There was plenty of time.

A few days later Rick addressed the problem again. He realized he had to become an "expert" on noise abatement in a very short time. The best way, he reasoned, would be to get as much information as possible and then call in a consultant once he was informed enough about the subject to be able to discuss it. The first thing he did was to call the librarian at the corporate headquarters and request all the literature available. It would probably mean becoming a "hermit" for a few days while reading everything he could about noise, but it had to be done. In the meantime he read some relevant articles Walt had copied from periodicals.

The next morning the bubble burst. Rick was just stepping out of his car when the security guard walked over and told him to go directly to the "Poly" department. There was a sense of urgency.

"What's up, Walt? Why are all the mechanics here?"

"We had a bad breakdown last night. We're losing $10,000 a day in production. As near as we can figure out, the screw feeder clogged-up and material jammed the dryer belt. Once the belt stopped it overheated the product and ruined everything. It's a mess. The workers say they couldn't hear the high temperature alarm because they both had their hearing protectors on."

"So what other bad news do you have to start off my day?"

"It's true, Rick. We've asked the workers from the other shifts and they've all had problems. They used to be able to tell when something jammed because product would stop feeding into the mills and the mills would suddenly get 'quiet'. They relied on the noise without realizing it.

The union steward backs up the workers completely. In fact, they'll agree to work without hearing protectors for a little while so there are no more jams or fires. This thing is back on the 'front burner' again."

"As soon as things get back to normal, I'll spend some time in this department to see EXACTLY how they operate. This has become a real priority."

The books had arrived from Headquarters, and Rick read them hurriedly while waiting for a call that "Poly" had started running again. There were articles about noise energy, reflective surfaces, frequencies, sound absorption, vibration transmission, and on-and-on. There was a lot to learn.

"Poly" wasn't running until the next morning. Rick spent a long day watching the operation. He noticed how the operators regularly left the bagging area to adjust the dryers, and how they were exposed to the loud mills while they stood on the work platforms adjusting the temperature settings and air flows. A few times one of the operators had to stop the feeder and remove a clog of gummy, undried polymer (when you listened, it was obvious that the empty mill had suddenly gone silent) before re-starting the feed. Also, a maintenance mechanic was summoned to change the drive-pulley ratios on the mill when product samples showed a lot of lumps: Rick never realized the mill speed was frequently changed to accommodate the product specs. After ten hours, Rick had seen enough. He now had a much better understanding of the operation of the department and the duties of the workers. He'd even learned the idiosyncracies of the department that were not so obvious, but were essential none-the-less. Now he had to find a working solution to the noise problem.

The following morning, right after coffee, Rick attacked the problem with a vengeance. He spread the blueprints of the "Poly" department on his desk and reviewed the entire layout. There had to be a solution.

"Suppose I put up a wall around the bagging area?" he thought. "I could separate the workers from the noise to lower their exposure. The workers are in the bagging area most of the time, so they get the most advantage from the lowered levels. The bagging area already has a ceiling because of the platform that supports the product hopper, so all I'd have to do is put a partition across the front of the area and it would be enclosed. I would need some glassed area so the workers could keep an 'eye' on the rest of the floor, but that should be no problem. I'd put in a central-

ly located door so the operators could go to adjust the dryers. I could even put in some sort of louver that could be adjusted to allow in just enough sound for the operators to listen to in order to monitor the mills. Of course I'd have to construct a special ventilation system, or even air conditioning, because this room would be pretty stagnant. And we might have to rewire all of the alarms and buzzers so they'd 'sound' in the bagging room, but that could be done. We'd need a large double door for the fork-truck that removes the pallets of bagged product after every shift--it would be a 'tight fit', but I think a good driver could get into the area without hitting anything. I think I'm ready. It's time to call in the consultant to evaluate my plan."

Questions

7) Who would put "pressure" on Walt if they knew about the noise problem?

8) Why do you think Walt--apparently a dedicated safety professional--was "stumped" and tempted to ignore the problem?

9) How many hearing-protection "earmuffs" should Rick have ordered?

10) What "signs" did Walt mean would be put on the doors?

11) Was Rick responsible for the jammed dryer?

12) Rick wanted to build a partition to block the noise from entering the bagging area. Is this a viable idea?

EXCESSIVE WORKPLACE NOISE IN THE "POLYMER" DEPARTMENT (C)

When the noise-control consultant arrived, Rick was eager to present his plan to isolate the bagging area from the mill noise with partitions. Still, Rick realized that too much enthusiasm might sway the expert away from his best judgment, so they reviewed their findings and experiences with him instead. The consultant charged a steep fee, and Rick wanted his money's worth of knowledge.

"Well, from what you fellows tell me, this is a tricky problem. I'd like to see the work site," insisted the consultant, "so that I can determine my plan of action. Sound is tricky stuff: it can bounce around corners, be carried along building steel, and even get 'trapped' between two reflective surfaces. I'm glad you studied this problem so well, though, because it's difficult to start completely from 'scratch' without any information."

"Logical" thought Rick, a little flattered.

Once they were in the "Poly" department the consultant didn't seem too interested in the noise problem--in fact, he only took one noise level reading around the mills. Instead, he asked questions about how the mills operated, and how often they needed service and maintenance. Did they need constant adjusting? How much air flowed into the mills to convey the ground product? Rick was surprised when, after only a few minutes, they were leaving "Poly" headed for Walt's office.

"Well, what do you think?" challenged Walt.

"I can see your concern. Those mills are very noisy. I got a reading of over 110. I guess that's what a one-ton bumblebee would sound like."

Before he could finish, Rick was telling the consultant his scheme: "I think we should partition the bagging area to keep out the noise."

"Oh?" queried Walt.

"Look," Rick continued, "we know that the mills make all the noise. We also know the workers are at the bagging stations most of the time. So, if we can isolate the workers from the mills we can lower their exposure. We can put in windows so the workers can watch the dryer area, and rewire the temperature alarms into the room. We can even put in double doors so the lift-truck can remove the pallets of bags at the end of each shift. By installing louvers we can control the sound coming into the room: we let in just enough so the workers can listen to the mills and check that

everything is O.K. Honeycomb partitions are lightweight, and the noise would be reflected away by the laminated surface. I estimate the project would cost about $10,000."

"That makes sense" said Walt turning towards the consultant. "Do you agree?"

"I can see that Rick has really thought a lot about this. I agree we should separate the workers from the noise, but I'm not sure a partition around the bagging area is the best bet. Remember, the bagging machines make some noises themselves, and if you put up partitions you'll 'trap' those noises in the bagging area. I don't think you'll get a substantial reduction in sound that way. Besides, even if you do reduce the levels in the bagging area it still takes only a short exposure to the loud mill area to push the average exposure levels way up. And if we forget about the average levels, the brief exposure to the high levels can't be very healthy, either. The partitions might work, but they would be expensive to install, require ventilation and rewiring, and the workers would still be exposed every time they adjust the dryers."

Walt was disappointed. "So now what can we do?"

"Rick was mostly correct," continued the consultant, "partitions are the answer. However, we should partition the mills and not the people. If we can stop the noise at the source, then workers can go anywhere in the department without harmful exposure. We should enclose the mills."

Rick nodded in agreement as the consultant explained his conclusion.

"The mills are very high-energy sources, and they broadcast sound into the air. The sound is 'trapped' between the large dryers, reflecting off the metal sides, and can't dissipate. If we put an enclosure around each mill the sound energy will be contained. Normally this can be risky when there's a motor involved because it can overheat if you cut off the flow of cooling air, but in this case that won't be a problem. Also, we'll have to make the enclosures simple to remove: I suggest a two-piece enclosure."

Rick watched as the consultant sketched the details of an enclosure (see Exhibit C-1).

"I'd also suggest lead-filled vinyl foam.* It really absorbs noise. This product bulletin contains charts expressing the sound absorbing qualities of the product I recommend for all the different thicknesses available, all based on standardized tests performed by the manufacturer. It appears the medium-weight foam will be adequate to absorb a sufficient percentage of the sound for your needs. I better check this chart of 'Transmission Loss' to make sure we have enough resistance to sound passing through the walls into the room. Medium-weight foam is adequate. I would avoid fiberglass or mineral fiber batts for this application because I'm concerned that the constant stream of cooling air would loosen the fibers. The batts work in some locations, but I'd use the foam here. It isn't expensive, and you'll only require a small roll. You'll need a strong enclosure. Build the enclosure from plywood--don't use sheetmetal--and glue the sheets of foam to the inside surfaces where it won't get caught or torn. I wouldn't put it on the innermost surfaces, either, in case you catch it on the mill when you install the enclosure: it could get caught in the pulleys."

"One more thing. You definitely should consider cutting the exit pipe from the mill and installing a flexible rubber coupling or piece of hose."

As soon as the consultant left, Rick brought the enclosure sketch to the carpenter's shop.

*Related References:

NIOSH Compendium of Materials for Noise Control, Publ. No. 80-116, May 1980

ASTM (E 596)04.06, Testing of sound-isolating enclosures

ASTM (C 423)04.06, Testing of sound absorption of acoustical materials by the reverberation room method

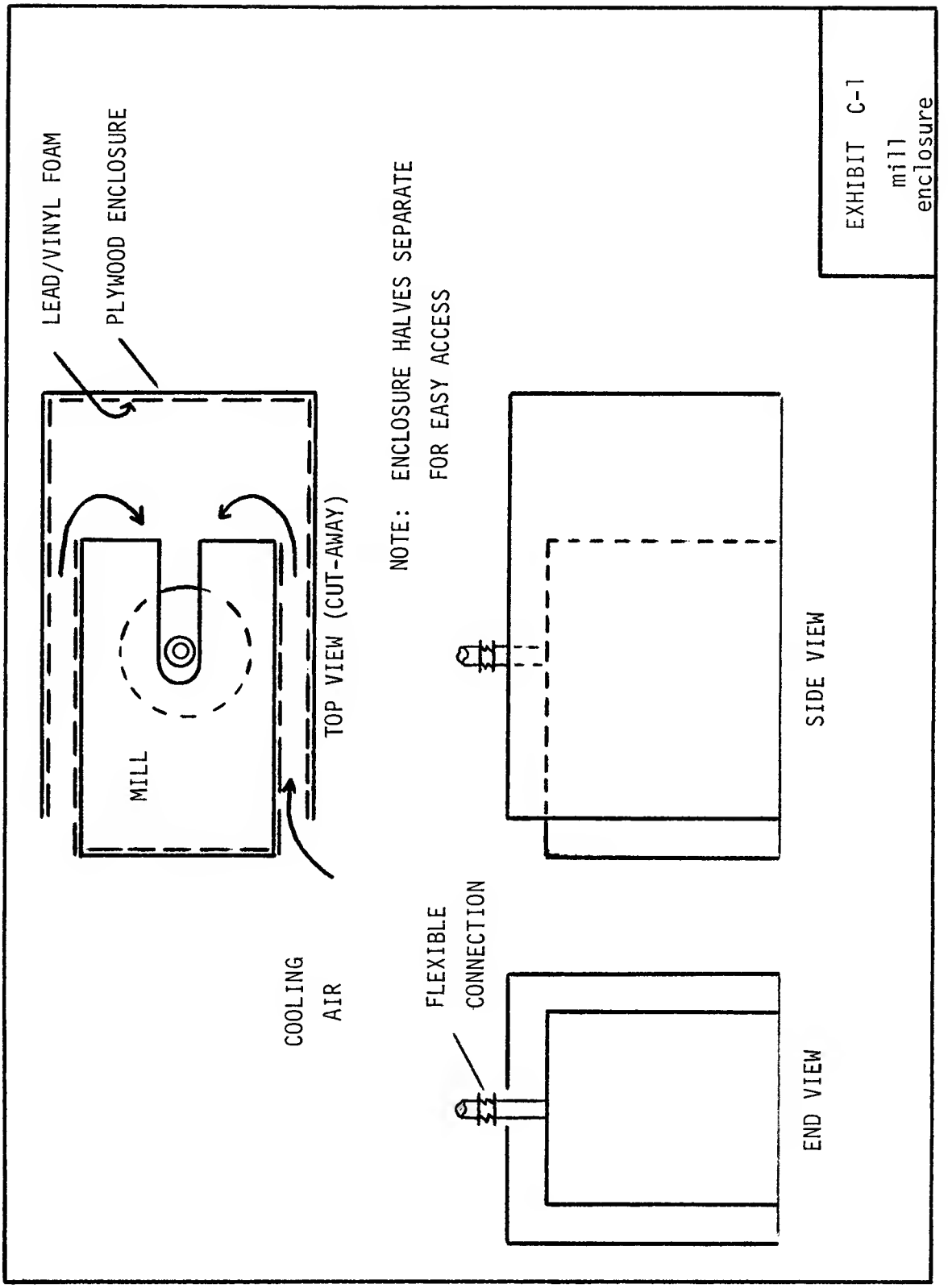


EXHIBIT C-1
mill
enclosure
LEAD/VINYL FOAM
PLYWOOD ENCLOSURE
MILL
TOP VIEW (CUT-AWAY)
NOTE: ENCLOSURE HALVES SEPARATE
FOR EASY ACCESS
SIDE VIEW
FLEXIBLE
CONNECTION
COOLING
AIR
END VIEW

Questions

13) Why wasn't the consultant worried about cooling the mill motors?

14) The enclosures had to be simple to remove--why?

15) "Don't use sheetmetal!" Why not?

16) When he sketched the enclosure, why did the consultant specify the lead/vinyl foam on the inside surfaces?

17) Why should Rick install a rubber coupling in the mill pipe?

EXCESSIVE WORKPLACE NOISE IN THE "POLYMER" DEPARTMENT (D)

On his way back from taking some measurements of railing heights at the solvent tank-farm the next day, Rick stopped by the carpenter's shop to review the progress on the mill enclosures. They were taking shape nicely. The shells were of plywood construction with tightly glued-and-nailed joints. All the exposed sawn edges were slightly rounded and sanded to reduce the chance of splinters, and the surfaces were painted with a heavy coat of gray paint that still smelled new. The carpenters were installing the leaded vinyl foam sheets to the inside of one of the enclosures as he walked in.

"This vinyl stuff is awful heavy! Tell me, Rick, what does it do?" asked the carpenter. "We ordered one roll of it yesterday, and it took two men to unload it from the delivery truck this morning. We're following the sketch you gave us for the enclosures, and we're applying the vinyl according to the directions that came with it. You glue it to the surface with contact cement and then staple it into place to hold it until the glue dries. C'mon, I'll show you the one we just finished."

The carpenter led Rick past the men working on the second enclosure to the other side of the shop (the carpenter made it a point to show Rick the fire extinguishers his men had ready while they worked with the paint and the solvent-based adhesives) where the finished enclosure sat. It was not very much larger than the mill it was to enclose, yet it would completely surround the mill. The top surfaces had been notched to fit around the powder-conveying pipe running from the top of the mill, and the inner surface was foam lined.

"That foam material is filled with powdered lead," explained Rick, "because it's a sound damping material. We knew we could contain a lot of the noise with a plywood enclosure, but the energy level inside the box would just go up and more noise would escape out through the air passage. This way the foam 'absorbs' the noise like a sponge so less can escape out the air passage to broadcast into the room. Also, less sound waves get into the plywood to be transmitted to the outside surface and then into the room again. A lot of times people use overlapping baffles and panels to block and absorb the noise, but we felt that would hinder the flow of air to the mill and overheat the motor. It's like moving into an empty house where even the slightest sound hits the walls and bounces around like an echo chamber--put down a thick carpet and hang some curtains, and the echo is gone. I considered it, but I just didn't think pink-lace curtains would look right in the 'Poly' department."

The carpenter laughed at Rick. "Get out of here! We have serious work to do."

Two anxious days later Rick received the phone call telling him both enclosures were done and were to be installed as soon as possible. He wanted to be there to see how the enclosures fit the mills, how easily they installed, and especially how well the noise was contained. On his way out of the office Rick grabbed the sound meter to measure the reduction in noise levels. On his way to "Poly" he walked past Walt's office to see if Walt wanted to see the installation too.

"Could you wait a minute for me?" asked Walt. "I want to take my copy of your noise-level readings from before we designed the enclosures (Exhibit A-4) and get some new readings for a comparison. I'd like to measure exactly how effective those boxes are."

"I just happen to have my meter along."

"You're really 'on top' of this thing, Rick. Let's go over to 'Poly'."

By the time Rick and Walt reached the mill area the carpentry crew had both enclosures in place. Walt was surprised they could be installed so quickly.

"Nothing to it. The halves of the enclosures just slide together and overlap. Perfect fit," bragged the carpenter, "and if you have to get to the mill to change the drive-pulley, you just slide the halves apart. One man can do it--we tried it."

"I think it's a good installation too. I watched one man pull a half away in one direction, and then pull away the other. Nice and safe." It was the union steward. He continued "I have to admit, this is pretty clever. Does it really work?"

Rick was already taking readings with the sound meter. He raised his eyebrows, and continued taking readings as he walked slowly around the enclosure. The mills were running--you could hear the high R.P.M. whine of the motors and you still had to speak up to be heard--but they were noticeably quieter. With his eyes riveted to the meter, he walked to the other enclosure. Rick held his hand near the opening of the enclosure to feel the invisible draft of air, and then took more readings. Slowly, he walked towards the bagging area, still watching the meter.

"Well?" inquired Walt impatiently.

Rick looked up. "Great! I'm getting readings over 90 at the mills themselves (see Exhibit D-1) but it drops away rapidly, and I read less than 85 by the bagging machines."

"Do you think the enclosures work too well? Can you hear the mills themselves?" Walt did NOT want a repeat of the breakdown.

"I'm not sure. I'll face away, and you turn a mill off for a minute. I'll try to tell when you do just by the noise."

A few seconds later Rick heard the sound of a mill slowing down. "It's off" he yelled.

After a pause, the sound surged with power. "Now it's running again."

Immediately the sound began to fade again. "Did you just turn the mill off again?" Rick questioned.

"Just testing your hearing" Walt chuckled. He had a look of satisfaction on his face.

"I'm pretty sure the workers can hear the mills if they jam. If not, we could probably cut a small hole in the enclosure until we get just enough sound to notice if the mills are running" stated the union steward.

At the start of the next shift Rick equipped the operators with the recording meters to do an eight hour exposure measurement. He chatted with the workers for a while, and it was obvious that the area was much quieter. It seemed more "relaxed" and less "frantic" too, but that was probably due to the absence of the irritating mill noises. The shift progressed: the operators bagged product as usual and made numerous dryer adjustments, so it seemed the test readings would be valid. The operators responded to the instrument alarm buzzers promptly, and Rick wondered if this were due to the buzzers being so much more obvious against the reduced background noise or because he was present and the workers wanted to be on their best behavior. Rick, perhaps smugly, concluded it was due to both the reduced background noise AND his presence. However, he had noticed that even the department phone sounded louder.

Suddenly one of the operators looked up. Rick was puzzled.

"Do you hear that, Rick?"

"Hear what?"

"I think one of the mills is quiet--I'm not sure, but I don't think it's getting any feed. I better check."

Rick followed the operator to the mill area. As they approached it became obvious that one mill was, indeed, louder than the other, signalling a probable jammed feeder.

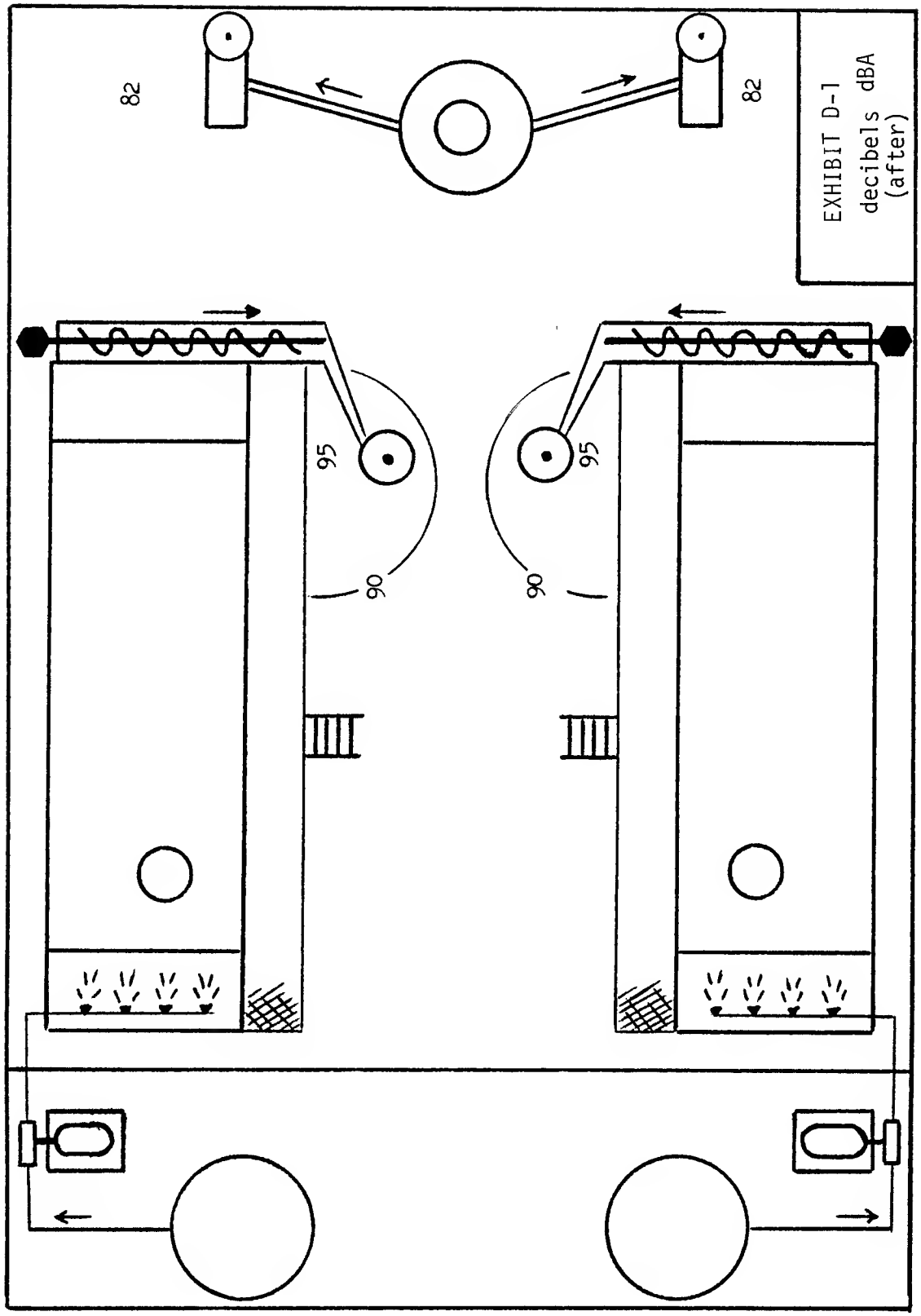
"Just as I thought," the operator thought out loud, "there's a clog in the screw feeder and no product is getting to the mill. I wasn't really sure because I'm not familiar with the new mill sounds. I'll turn off the feeder."

Rick watched as the operator followed procedure: first he turned off the clogged feeder and it stopped immediately; then he poked at the clog of hardened material with a broom handle until it broke apart; finally, he looked to verify all personnel were clear of the machinery and he pressed the "start" button. The feeder jolted to life and material slid into the mill again. Even through the enclosure the noise of the mill pulverizing the dried product was loud and powerful. And the operator had heard it.

The remainder of the shift was routine and uneventful. The meters were unstrapped and turned off, everyone said "hello" to the next shift and then they went home for the weekend.

Bright and early on Monday Rick took the meters to Walt's office with the results. The averaged exposure for the baggers was just a bit over 85 decibels--a great reduction in noise--and Rick was happy. He explained his observations of the apparent reduction in workplace stress due to the quieter surroundings, and the clarity of the instrument buzzers and the telephone, the total cost of $1,000 for the enclosures, and especially the incident of the clogged feed and the operator's ability to hear it. Walt listened intently.

"Rick, it sounds as if this problem is licked. I'd like to ask one more favor, though--could you write-up a thorough case history of the project for me? Start from the noise surveys that indicated we had a problem, then detail your own tests that verified my results and showed high levels around the mills. I want you to list that we took immediate steps to protect the workers with inexpensive hearing protectors. Show how the workers couldn't hear the alarm buzzers, ruined a lot of product, and almost started a


82
82
EXHIBIT D-1
decibels dBA
(after)
95
90
95
90

Discussion

1) Walt (the Plant Safety and Health Manager) doesn't seem as involved with this project as Rick, and at one time even considers just ignoring it altogether. Rick knows Walt to be a dedicated professional. Why do you think Walt acted as he did?

2) After taking sound-level readings, observing the operation of the department, and studying all the literature on noise control, Rick concluded the best approach was to partition the bagging area. The solution chosen was the enclose the mills. Was Rick wrong?

3) "In the 'old days'" commented the union steward. Do you feel there are more or fewer employers today than "in the old days" who would accept workplace noise?

4) What do you think of Rick's "double standard" analogy of silicosis and hearing-loss?

5) Assume you agree with the consultant and choose to stop the noise at the source--what other ways can you think of?

EXCESSIVE WORKPLACE NOISE IN THE "POLYMER" DEPARTMENT

INSTRUCTOR'S GUIDE

Brief:

A "Real-Life" case involving workplace noise at a polymer drying/grinding/bagging facility that includes sound measurements, short-term worker protection, process and economic considerations, and source identification and isolation as a permanent technical solution. Drawings illustrate equipment layout and decibel readings.

Summary:

This case is seen through the eyes of "Rick," the young Safety Engineer at a large processing complex. He is informed of high noise levels in the polymer grinding department by the facility's Safety Manager, and is assigned to "look into" this problem. Rick performs sound measurements to determine noise levels and locate the sources. He subsequently suggests personal hearing protection for the exposed workers as a temporary safety measure while seeking other solutions with the assistance of a consultant. Together they study the workplace and the noisy pulverizing machinery before finally designing lead-lined equipment enclosures to isolate the noise sources.

The problem starts with a phone call to Rick by Walt (the Safety Manager) to meet and discuss test results indicating excessive noise exposure of workers in the "Poly" department. Rick reviews the layout of the department (Exhibits A-1 and A-2, study) which is new and very profitable: The process consists of a vessel where the polymer reacts to form a viscous syrup that is sprayed into a heated conveyor-belt dryer to remove all water; the dried material is pulverized in grinding mills, and finally packed into 50 lb. bags by workers. There are two production lines, side by side, that run continuously and often require adjustments by the workers.

At the meeting Rick is given the very vague and encompassing assignment of "looking into" the noise problem. This he begins immediately, first by reviewing the instruments and verifying their calibration, and then by repeating the noise survey with recording/integrating sound meters, all of which shows that averaged worker exposure is, indeed over 90 dBA. With "real-time" meter in hand the Safety Engineer inspects the workplace and realizes that the grinding mills (Exhibit A-3, study) are very loud and the sound is bouncing from the walls of the dryers, creating high

noise levels in the alleyway between the dryers where the workers stand as they adjust the equipment. Meter readings (Exhibit A-4, study) confirm this.

Upon relating his findings to Walt, Rick feels the Safety Manager would like to mislead everyone and "sweep the study under the carpet." Upset by this response, Rick ponders the consequences of neglecting workplace safety, especially workplace noise, and expresses concern for the workers' hearing. By comparing the slow nature of hearing loss to the insidious onset of silicosis, however, Rick convinces himself that high noise exposure is a real workplace hazard and decides to recommend personal hearing protection "earmuffs" as an immediate (and low cost) solution. He feels conservative safety measures are a better recommendation than rashly suggesting either closing the department or callously ignoring the noise.

Once the hearing protectors are purchased and the workers are being instructed in their use, we learn that the Union Steward is very aware of workplace safety (having been sent to safety training by the Union in order to safeguard its members) and probably would have caused legal challenges if the management chose to ignore the noise problem. He discusses how common worker deafness really is, and how it was once considered a normal part of certain jobs "in the old days." Long on experience, the steward suggests the "earmuffs" will be uncomfortable in hot weather, and a long-term solution is required.

The pressure is on Rick again. He realizes many companies have safety information and expertise and requests all the information on noise control he can get. He also scans periodicals for the many relevant "how to" articles they often publish to inform readers. Unfortunately, he doesn't get a chance to read them before he is blamed for a disastrous equipment breakdown that occurs when workers claim the "earmuffs" prevented them from hearing alarm buzzers. Rick realizes he didn't really study the process he tried to change, and spends time learning the operation thoroughly in order not to overlook any factors such as alarm buzzers.

With a solution required immediately, a consultant is retained. Rick, Walt, and the consultant examine the "Poly" area and return to Walt's office to discuss ideas. Rick has devised elaborate schemes of partitioning the building and re-wiring the equipment, but discussion shows these plans to be excessive for the benefits derived. Instead, the consultant suggests isolating the source--the mills--with special enclosures, the design of which is based on the unique type

of equipment involved. Lead-filled sound shielding is specified (Exhibit C-1, study).

The enclosures are fabricated as Rick details the design considerations to the carpenter. Everyone is present as the enclosures are installed, and all are impressed that the solution could be of such simplicity. Meter readings show greatly reduced noise levels (Exhibit D-1, study) in the workplace, but Walt is skeptical and tests to determine whether or not workers could hear if the mills were suffering mechanical problems with the enclosures in place. Rick believes he can still hear the mills clearly. It is time to re-survey worker exposure.

The operators are equipped with recording sound meters for an eight hour survey as Rick observes department operations. Everyone realizes how irritating the excessive mill noises were now that they are silenced, and working conditions are much more pleasant. During the course of the survey everything runs normally, indicating representative sampling. The equipment clogs once, and Rick is pleased to note that the operator could still hear the machinery noises well enough to determine the need for maintenance.

When Rick presents the survey results indicating considerably reduced worker exposure, and details how the operators can still hear the machinery well enough to operate it properly, Walt is pleased. So pleased, in fact, that he asks Rick to summarize the work as a case report to be presented at an important company meeting. Both realize this would be a good chance to "show off" to the rest of the company, and also a way to offer information and experience to others who might be confronted by similar problems. Rick begins writing the study.

Post-Script:

It is the major intent of this case to stress that workplace safety problems often have many considerations that might not be obvious in the strict application of an engineering solution: human behavior, interactions, and idiosyncracies are presented to define the problem, guide the effort, and shape the solution. Indeed, the case is seen through Rick's eyes in order to use his observations and thoughts to express what otherwise could easily become an impersonal technical treatise. Other factors that affect human decisions--those of morality, legality, and economics--have also been introduced, and, while not as easily defined or evaluated as a decibel reading, weighed in Rick's thoughts. For example, it is unknown whether or not the

company would be moral enough to expend effort (dollars) at a profitable operation if not for legal responsibilities and fear of lawsuits. Would it be morally or economically justifiable to close the facility and lay-off all the workers being exposed to high noise levels just to avoid possible fines or lawsuits?

It is also the intent of this case to present technical information. To this end the design of the process from raw material to bagged product is detailed, as are some of the techniques and equipment for noise surveying, project researching, characteristics of sound, methods of noise control, materials of construction, and even maintenance procedures. For example, the mill enclosures are specified to be of plywood construction instead of sheetmetal, and lead-filled vinyl foam is used to line the enclosure for sound absorption. Drawings are used to convey much of this information and questions are added to stimulate text review and discussion.

Answers to Questions

Note: Overviews included for emphasis and amplifications

Question Number

1) He didn't give any assignment. Walt asked Rick to "look into" the problem without giving any specifics or directions, and thus was very vague. Even if Rick doesn't report in authority to Walt (the Safety Manager must "request" rather than "assign" work) the lack of definition can only cause confusion.

   The assignment to "look into" the problem is very vague. Without at least some guidance Rick is operating as a "free agent" who might (or might not) be fulfilling the assignment as perceived by Walt. At the best, Rick might have to consume precious time to redo actions that might not meet with Walt's unstated expectations, and at worst considerable anger could develop that could stop the project and leave the workers to suffer. (While we determine later Walt is unfamiliar with noise control, it is no excuse for not working out a plan or schedule with Rick.)

2) A - What safety priority should he assign to noise exposure? Should it rank as immediate as fire or electrical shock?

   B - Should he warn the "victims"?

C - What kind of proof did he have that high exposure existed at all?

Many considerations could be going through Rick's head: he has no real assignment and must develop his own plan and schedule. This question is deliberately vague to show the problems that can arise from a poor job assignment as detailed in (1).

3) Rick didn't know for sure that the exposures were high. He didn't want to possibly alarm the operators needlessly.

Rick did not want to alarm anyone if Rick, himself, was not sure. Also, if the workers believed they were in imminent danger they could stage a walk-out, or picket, or possibly sabotage equipment to cause a shut-down.

4) Rick wanted to make sure the operators wore the recorders properly and didn't tamper with them or place them on a noisy machine "as a joke."

Operators might tamper as a "joke." They might even try to convince everyone readings are intolerably high to justify a vacation or some type of "hardship" bonus in their paychecks. Surveys should be representative.

5) The sound-level readings would not be representative if, say, all the equipment was shut down for yearly maintenance.

Surveys should be representative. In addition, by maintaining a good rapport with the operators Rick could rely on information they gave him and ask for assistance, etc., to make surveying easier.

6) The hard, smooth, sheetmetal dryers reflected all of the mill sound, keeping the sound "trapped" in the alleyway.

In addition to the large dryers containing the mill noise, there would be noise from the dryers themselves (conveyor-belt drive, furnace draft fans, screw conveyor drive, etc.).

7) There are many organizations charged with the responsibility of maintaining workplace safety, including the Plant Manager, the Main Office of the company (especially the "Corporate Safety Manager"), the worker's union (which could file a grievance), and various Municipal, State, and Federal agencies (e.g., local Health

Departments, O.S.H.A.).

The Plant Manager would be assumed to be the highest ranked manager on site. Also Union/Company Safety Committees are sometimes empowered by agreement, not to mention the foreman or "Poly" department manager.

8) Ignoring a problem is a common human response to problems one can't easily see or understand--"the ostrich response."

We do not know Walt's entire schedule. It is possible there were other safety problems of more immediate nature (either by type [fire or explosion danger, etc.] or by sheer number of people impacted) that demanded his attention. Even so, it would be poor practice to keep Rick uninformed and wondering what is expected next.

9) For personal hygiene reasons, Rick should have ordered at least enough for each worker to have his own set. Also, there should be extra to replace loss, be available for miscellaneous workers assigned to the department (including Rick and Walt), etc.

Personal hygiene weighs heavily here. Also, one must anticipate "wear and tear" of equipment.

10) "Hearing Protection Required in this Area."

Such signs serve many important purposes including: reminders to workers to wear their equipment to protect themselves; proof that the company wants to protect its workers and makes such efforts (Legal--is not negligent of worker safety); supporting the rule that hearing protection is seen as a job requirement in case it is necessary to discipline or dismiss a worker for continually ignoring safety rules.

11) Yes. Even though it would be a hard sequence of events to anticipate, Rick should have at least asked the foreman, workers, and steward if they thought the use of "earmuffs" would interfere with their job functions. Learning the "Poly" operation after the breakdown is "closing the door after the horse escapes."

While it is possible an aggrieved or hostile worker(s) could "fake" not hearing an alarm in order to point a finger at Rick, it would still be considerably in Rick's favor if he had scrutinized the operation better and possibly even asked (or tested) whether or not the

alarms were audible.

12) No. The greatest level of noise exposure occurred in the short time of adjusting the dryers. Even if the noise were reduced a few decibels in the bagging area, a worker would easily be overexposed by spending just an extra minute or so in the mill area.

The very nature of the non-linear decibel scale shows how workers would be exposed to much greater noise levels near the dryers than at the bagging stations (partitioned or not).

13) The mills drew a large flow of air to convey the ground product--this large flow of air would cool the motors.

The cooling requirements of instruments and motors are often neglected for the sake of weatherproofing or safety enclosures, often resulting in reduced equipment-life.

14) The mills required frequent maintenance and the drive speed had to be changed often to grind different product grades.

If a device such as an enclosure is too complicated, bulky, or even heavy, it often becomes unpopular with the people who have to assemble or move it, and they eventually neglect it.

15) A thin sheetmetal enclosure would act like a drum and transmit the noise well. Thick, rigid wood does not resonate.

Most common metals--excluding lead--transmit sound well. Sheet lead might be considered, except that it has poor structural qualities.

16) A - Foam is soft and would be easily torn in a busy factory environment if placed on the exterior.

B - The foam absorbs noise well, while the dense, limp lead retards transmission and facilitates damping. By lining the inside surfaces noise would not be reflected off the plywood surfaces to escape into the room through the air openings, and would not penetrate the enclosure walls.

Mechanics, anxious to repair a broken mill or maintain production rates would surely rough-handle the enclosure, so it is better to put the soft foam out of

harm's way. If the enclosure required handling with "kid gloves" it would become unpopular (see overview 14).

17) Metal usually carries sound well. The metal pipe carried the sound out of the enclosure and acted as an antenna to broadcast the energy into the room. The rubber isolated the mill.

In classic old western movies the "outlaws" are always shown with an ear on the tracks as they listen and wait to rob the mail train--the metal tracks carry the sound of the approaching train better than the surrounding air. If the continuity of the metal were interrupted with a length of a poor conductor (e.g., rubber or lead), the signal would be stopped.

Discussion--an Overview:

Note: The discussion topics are broad and designed to allow many thoughts and opinions. These overviews are provided solely to aid in starting a discussion, and are not intended to be the "only" or "correct" answers.

1) We have already cited two possible reasons--the "ostrich" response to fear of the unfamiliar, and/or the problem of priorities--but we must remember we are dealing with human beings: Walt could have domestic or financial difficulties at home, could have the flu and feel ill, or could even be recovering from his daughter's wedding reception the night before!

2) Considering only noise control, Rick's solution was not nearly the best (see question 12). However, if there were other considerations such as excessive dryer heat or grinding dust, an enclosed and ventilated area becomes more viable: workers could put on their hearing protection only when work outside the enclosure was required.

3) This is probably impossible to evaluate. However, with the considerable protective, enforcement, and educational efforts of the last decade, the workplace has become considerably safer.

4) Both silicosis and hearing-loss are caused by environmental agents, and both are slow, progressive, and irreversible. In both cases, the causative agents can be controlled by protective equipment (masks, "earmuffs")

or engineering controls (ventilation, shielding). Hearing-loss is not, however, directly life threatening, while silicosis is.

5) A - Mount the mills on rubber vibration dampers.

B - Coat the metal conveying pipes with insulation lagging.

C - Install porous sound-absorbing panels on the walls, ceilings, etc., near the mills. (This is often done in theaters and recording studios.)

D - "Curtain-off" the mills with porous sound-absorbing panels (provide a maze of surface area).

E - Install "intake silencers" (similar to an auto muffler, but in reverse) on the mills.

F - Spray-coat the mill exteriors with sound-damping elastomeric coatings.

A set of slides (based on figures used in the case) is available for purchase from:

Elder Photographic, Inc.
Pugh Building
Pike and 5th Streets
Cincinnati, Ohio 45202
(513) 621-5015